SEDIMENT ACOUSTICS

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award # N00014-94-1-0258
shallow water and high frequency acoustics

LONG TERM GOALS

The long-term goal of our work in sediment acoustics is to develop a practical as well as physically meaningful model to describe geoacoustic wave propagation in marine sediments on
the basis of a set of primitive physical variables.

SCIENTIFIC AND TECHNOLOGICAL OBJECTIVES

The principal scientific objective of our work has been to develop a mathematical model that is
able to predict wave velocity and attenuation in the sediments found near the seafloor. Specifically, the model has been designed to accept as input parameters certain fundamental
primitive variables, such as grain size, porosity, grain density and gas content that are directly
related to the geological processes producing the wide range of sediments that are encountered in
the world's oceans. A number of auxiliary technological objectives have also arisen in the course
of our work related to remote sensing and in-situ measurement of sediment geoacoustic properties. One of these objectives has been to develop a set of tools that allow the measurement of velocity and attenuation as well as certain related geotechnical variables such as
shear strength as a function of areal position and depth in the sediment column. These measurements provide the "ground truth" for assessing the validity and usefulness of the basic geoacoustic model.

APPROACH

Our approach has been to develop a theoretical geoacoustic model based on the classical Biot theory for porous, fluid-filled media. The model reflects the influence of variables such as porosity and overburden pressure and includes several kinds of intrinsic attenuation that are important in different kinds of ocean sediment. We have performed extensive field and laboratory experiments aimed at determining appropriate input parameters as well as checking the validity of the model predictions. Much of our earlier

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 1997**	2. REPORT TYPE	3. DATES COVERED **00-00-1997 to 00-00-1997**

4. TITLE AND SUBTITLE **Sediment Acoustics**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Lamont-Doherty Earth Observatory of Columbia University,Palisades,NY,10964**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**3**	

work is described in the monograph "Sediment Acoustics" (Springer-Verlag, 1989). More recent progress, especially the results of extensive field work, has been described in a series of technical papers and is being incorporated into several new chapters in a second edition of the monograph to be published in the near future. Over the past several years we have participated in a number of field experiments in cooperation with other investigators such as T. Akal at SACLANT Undersea Research Center in LaSpezia, Italy and M. Richardson at the Naval Research Laboratory, Stennis Space Center. During this work several new testing techniques were developed to measure in-situ properties of the sediments immediately beneath the seafloor including shear wave velocity and attenuation for both vertically and horizontally polarized wave motion, and undrained shear strength based on quasistatic cone penetration tests. In addition, sediment cores taken at each site were analyzed to obtain porosity, grain size distribution and other fundamental properties, the objective being to establish the ground truth at each test location and develop correlations between such quantities as in-situ shear wave velocity, undrained shear strength and porosity.

WORK COMPLETED

During the past year our research team, which includes R. Stoll and I. Bitte from Lamont-Doherty and R. Flood from the Marine Research Lab , SUNY, Stony Brook, participated in two major field experiments, one a NATO Rapid Response Exercise in the Bay of Saros, Turkey aboard the Dutch ship H.M. Tydeman and the other in the Gulf of Mexico at the NRL test site near Ship Island. During these cruises expendable and retrievable seafloor penetrometers were deployed, cores were taken and the results compared with the classifications produced by several acoustic seabed classification systems such as "Roxann" and the NRL ASCS system and backscatter measurements made with an 80 kHz source. In addition the LDEO penetrometer was used in a survey of bottom sediment properties in Port Jefferson Harbor, Long Island , New York. Theoretical work carried out during the year included modeling the soft, gassy sediments of Eckernforde Bay, over a wide frequency range using the Biot theory in order to match field data ranging from shear wave velocities for waves with a frequency of only a few Hz to p-wave velocities measured at 400 kHz [1]. Other theoretical work included the extension of our mathematical model to include the effects of gas bubbles and their resonance using the operator suggested by Biot in his 1962 papers [2].

RESULTS

Our field work over the past two years has demonstrated the feasibility of classifying the seabed sediments with respect to certain geoacoustic and geotechnical properties by deploying expendable probes which impact the bottom and measure the penetration resistance of the sediment. The penetration resistance, which is controlled by the undrained shear strength of the sediment, has been found to correlate well with sediment shear wave velocity as well as sediment porosity. With this information it is possible to make a reasonable estimate of the full geoacoustic response of the sediment with the aid of the mathematical model that has been developed using the Biot theory.

IMPACT AND RELATIONSHIP TO OTHER PROJECTS

While our primary interest has been to model geoacoustic properties of the sediment, a number of tools developed for our field work have direct applications to other areas of interest to the Navy such as mine counter-measures. As an example, the penetration resistance measured by several different types of probe we have developed is directly related to the bearing capacity of the sediment which is of prime importance in studies of mine burial in the seafloor. These probes have been used to map critical areas in two recent NATO exercises aimed at Rapid Environmental Assessment.

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